Growing Microgreens for NASA: from simulated microgravity to parabolic flights

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Fellow in the NASA Postdoctoral Program

Presented to: Ryerson University, February 2022

My crop of choice: Microgreens!

- Small space to grow
- Rapid turn around
- Large variety
- Dense nutrition
- Yummy

Sandwich with Scarlet Frills Mustard microgreens.

Background

Sustainable food production with plants

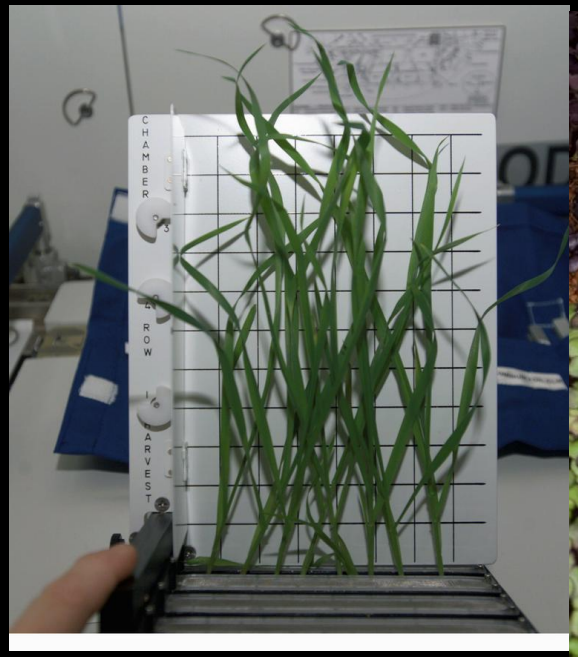
- Reduces mass
- Provides necessary nutrients

Microgreens

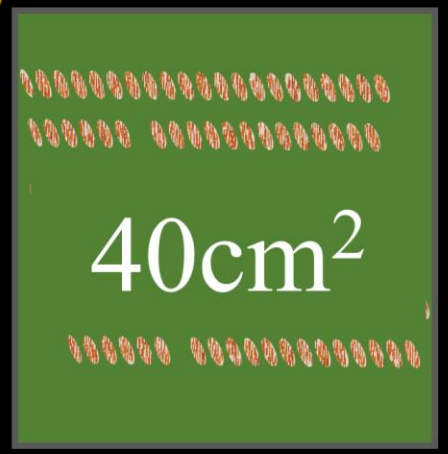
- Supplement to prepackaged diet
- Not yet grown in space
- Densely sown
- Potentially high microbial counts

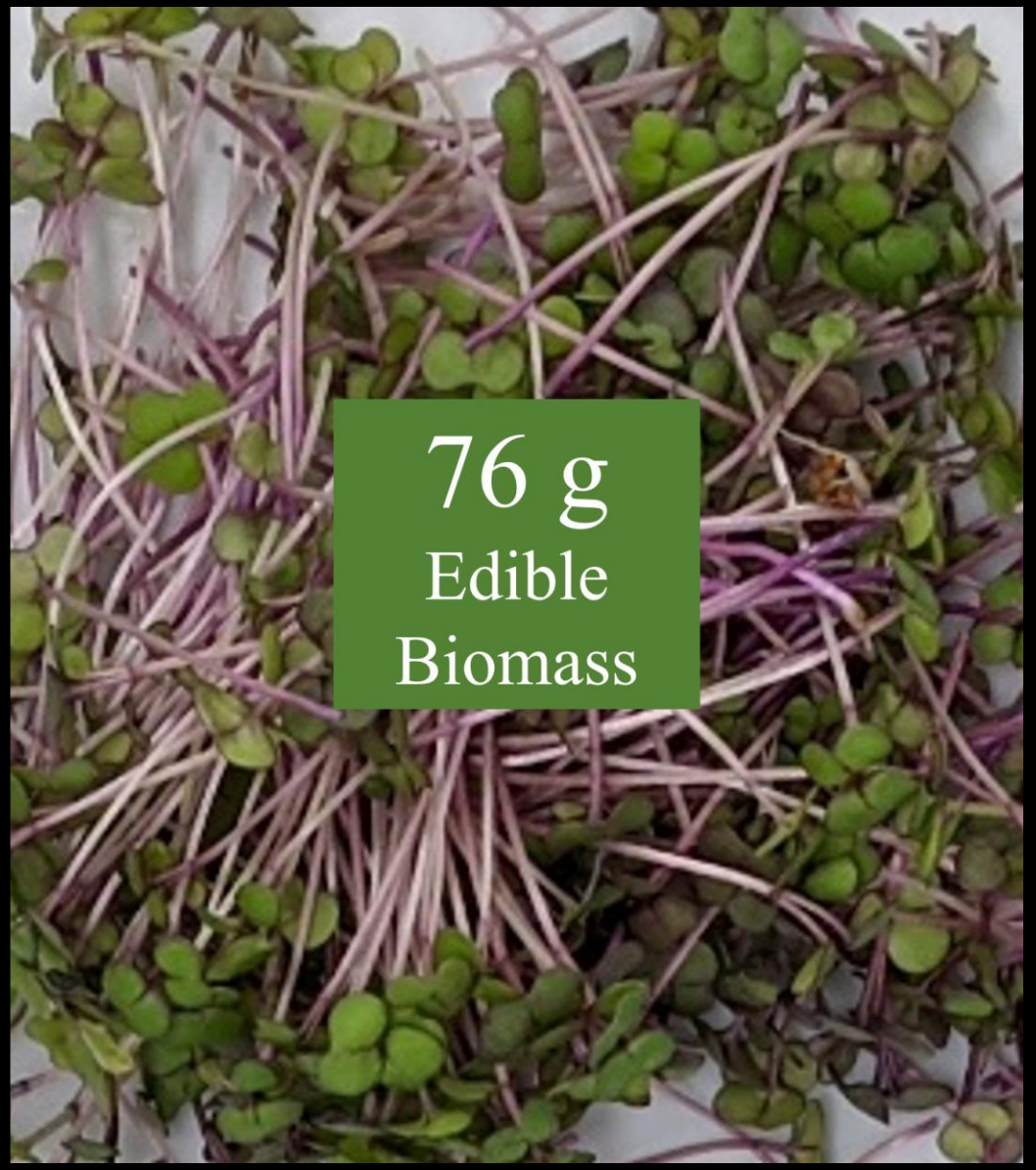
Diversity of Microgreens

- Wheat grass
- Cabbage
- Pak Choi
- Kale
- Chia
- Basil
- Mint
- Pea
- Sunflower
- Lettuce
- Watercress
- Fennel
- Moringa
- Mustard
- Cress
- Kohlrabi
- Radish
- Carrot
- Buckwheat
- Beet
- Spinach
- Any crop plant that can be grown from seed and has edible leaves at this stage in development!



Potential Yield





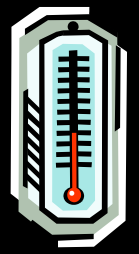
Health Benefits of Microgreens

Xiao, Z., Lester, G. E., Luo, Y., & Wang, Q. (2012). Assessment of vitamin and carotenoid concentrations of emerging food products: edible microgreens. *Journal of agricultural and Food Chemistry*, *60*(31), 7644-7651.

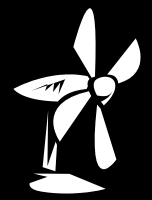
- USDA researchers showed microgreens have dense nutritional content.
- Contains vitamins that are lacking for Astronauts.
- Dense nutrition comes along with intense flavors.

	Vitamin K (µg/100g) FW		**Vitamin C (µg/100g) FW**	
	microgreen	mature	microgreen	mature
Radish	180	1.3	95.8	14.8
Mizuna	200	2.3	42.9	14.1

The Spaceflight Environment

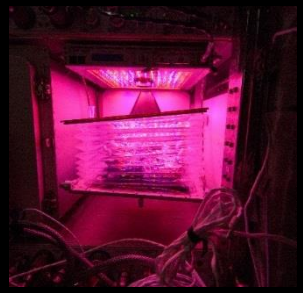


No natural thermal buoyancy.

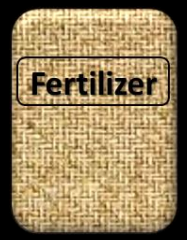


O_2 CO_2

Minimal power available.



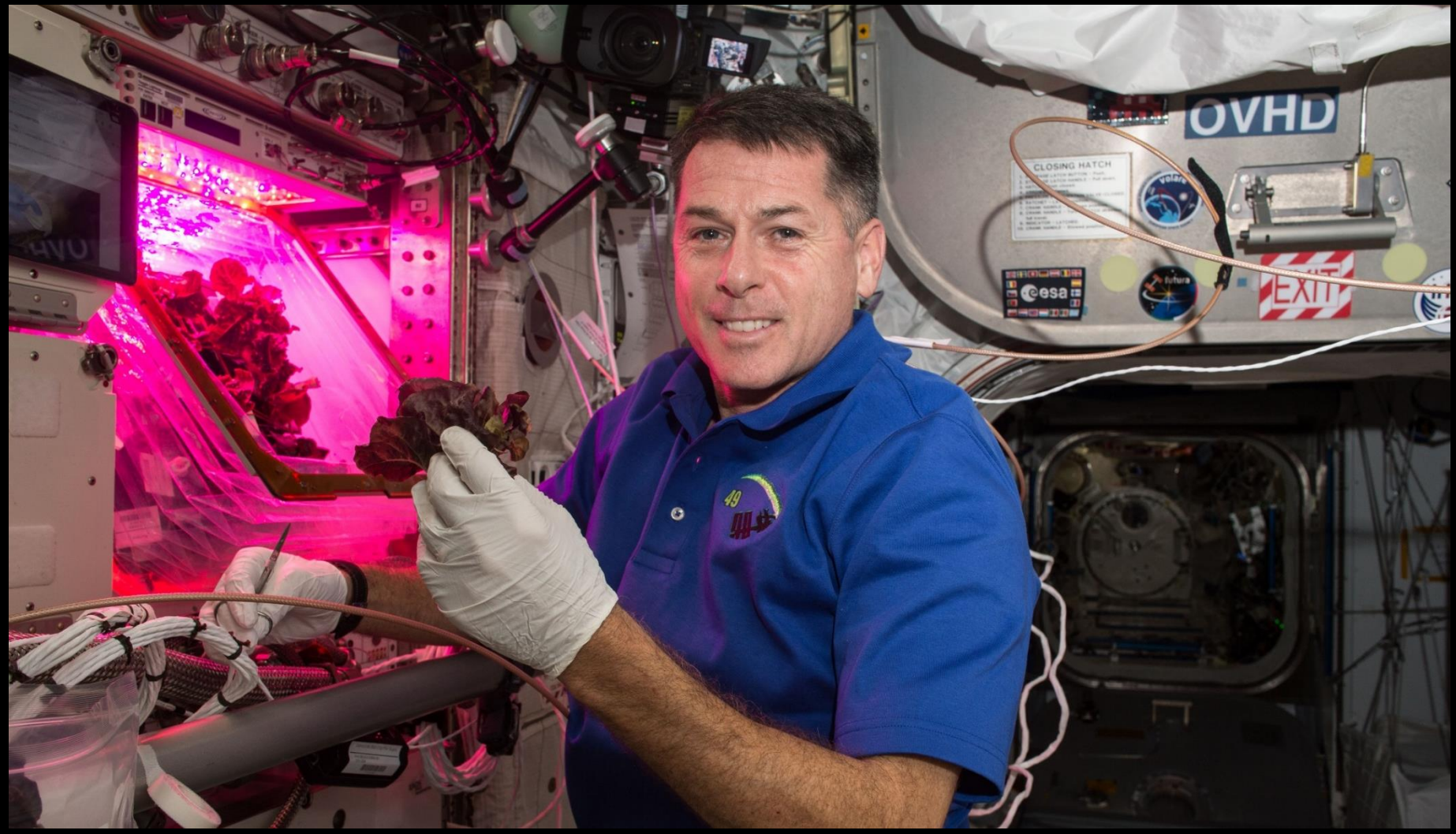
Water and air don't mix.



Fertilizer is heavy. Recycle.

Water in Spaceflight

Food Crops on the ISS

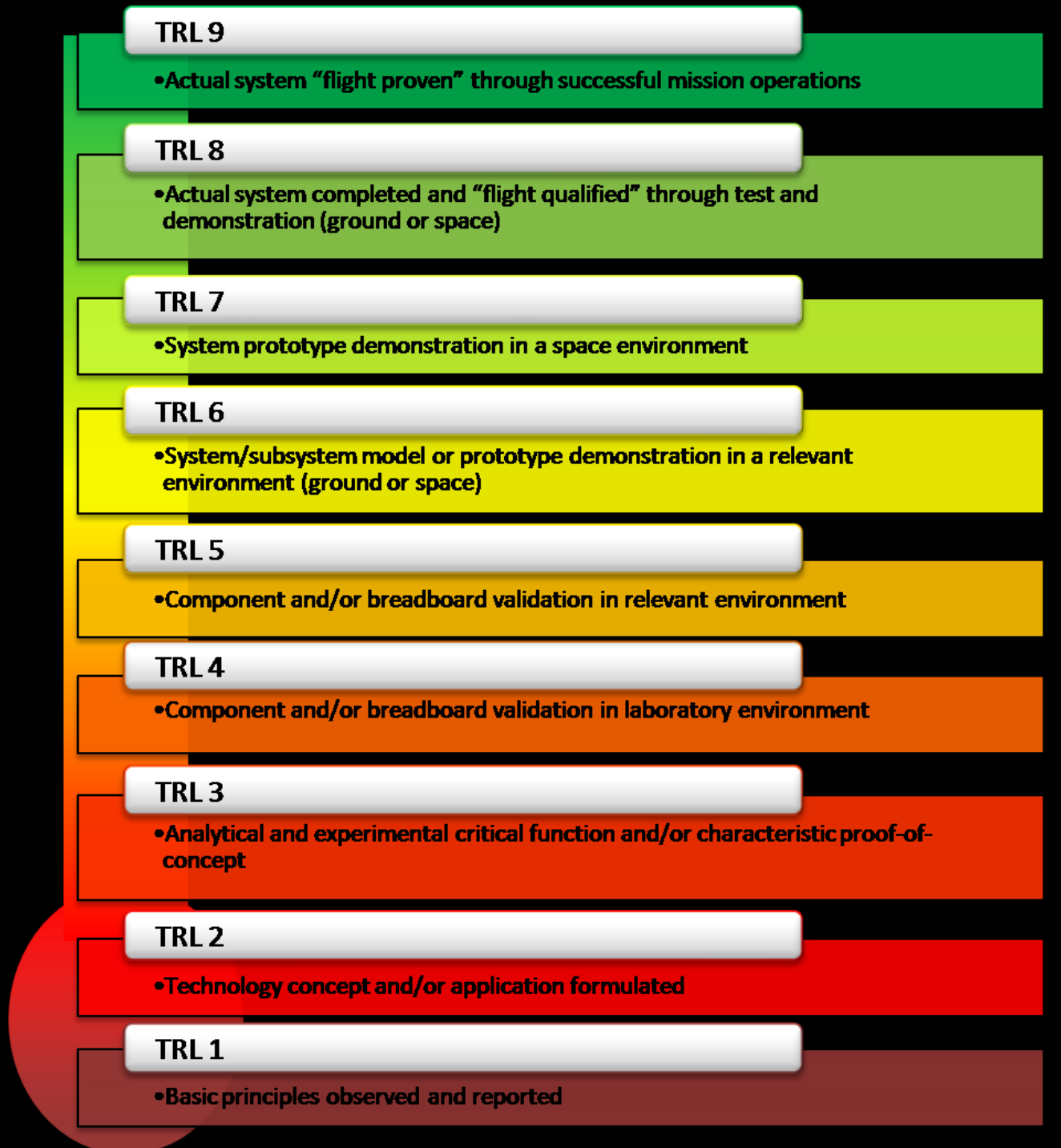


Crop Readiness Levels

Romeyn, M., Spencer, L., Massa, G., & Wheeler, R. (2019, July). Crop readiness level (crl): a scale to track progression of crop testing for space. 49th International Conference on Environmental Systems

CRL	Title	Description
1	Basic Crop Testing	Identification of candidate crop at cultivar level. Preliminary assessment of morphology, consumable yield, germination, and mission application.
2	Cultivar Screening	Detailed assessment of plant dimensions at maximal growth, pollination and germination requirements identified, harvest index quantified.
3	Relevant Environmental Testing	Testing at ISS simulated environmental conditions. Currently this is elevated CO_2 (~3000 ppm), ISS temperature (21-24 C), RH (38-44%), and LED lighting absent of UV. Adverse physiological responses identified.
4	Seed Sterilization	Identification of acceptable seed surface sterilization protocol.
5	Flight-like Testing	Testing in flight or flight-analog hardware at flight environmental setpoints.
6	Chemistry & Organoleptic	Elemental and mission-specific nutritional testing conducted at flight-like conditions. Organoleptic and sensory analysis conducted.
7	Baseline Microbiology	Baseline microbiological and food safety characterization conducted under flight-like conditions.
8	Grown in Space	Crop successfully grown to maturity in space.
9	Consumed in Space	Sanctioned consumption by crew in space.

NASA's Technology Readiness Levels



Lettuce Harvest

Fun With the Harvest

Microgreen Harvest
On Earth vs Microgravity

Microgreen Harvesting Techniques

We tested harvesting techniques with a parabolic flight using a glove box on loan from Dr. George Pantalos.

Microgreen Harvests in Parabolic Flights

Our Team: Chris Bermudez, George Pantalos, Gioia Massa, Larry Koss, LaShelle Spencer, Lucie Poulet, Jacob Torres, Christina Johnson

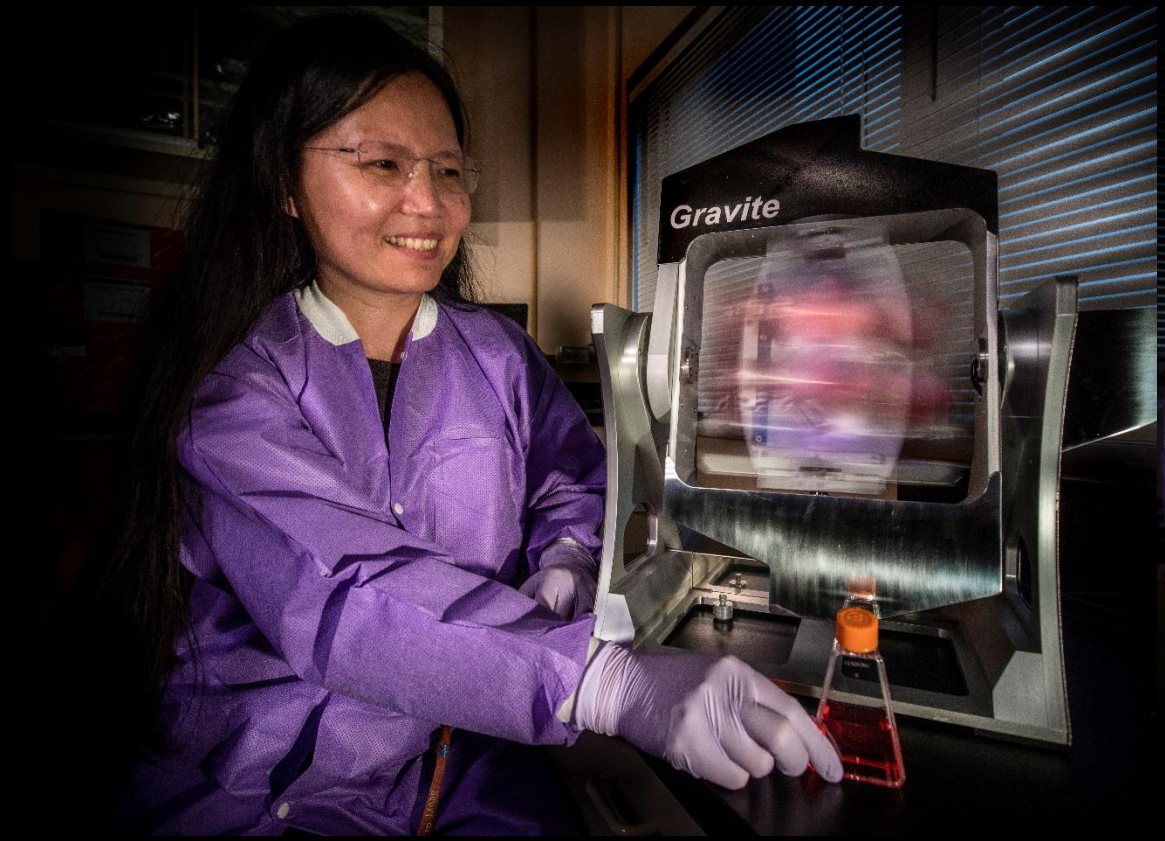
Sometimes things went really well…

Applying what we learned…

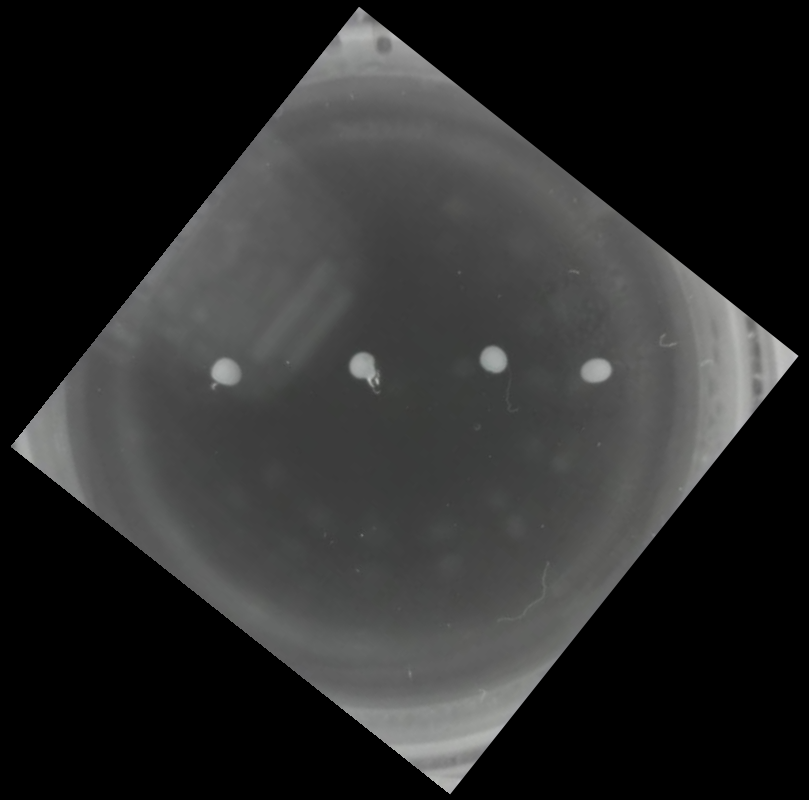
- Microgreens on microgravity simulators

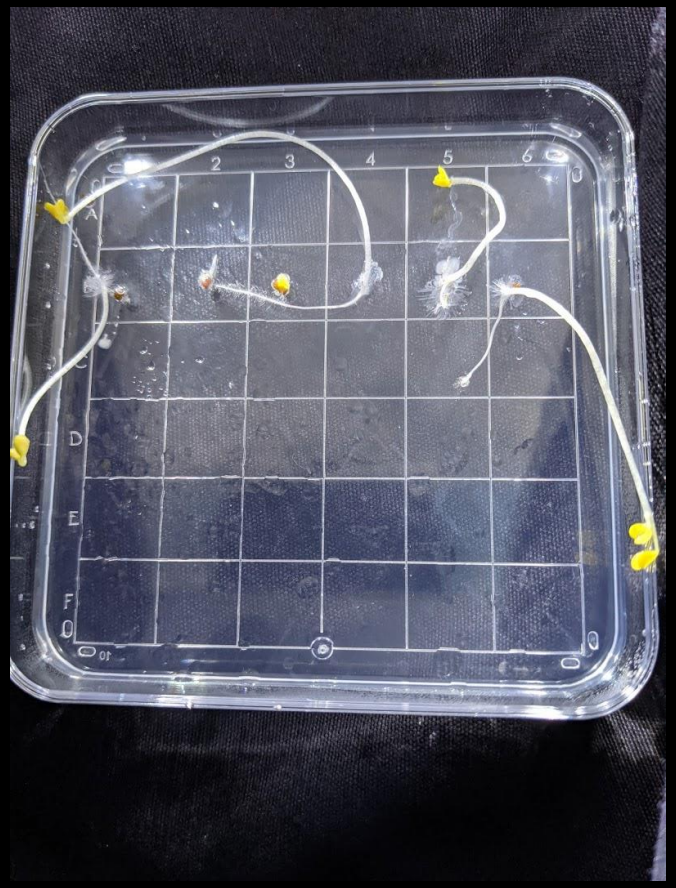
Daikon radish microgreens at harvest.

Microgravity Simulation Support Facility



Microgreens in Simulated Microgravity





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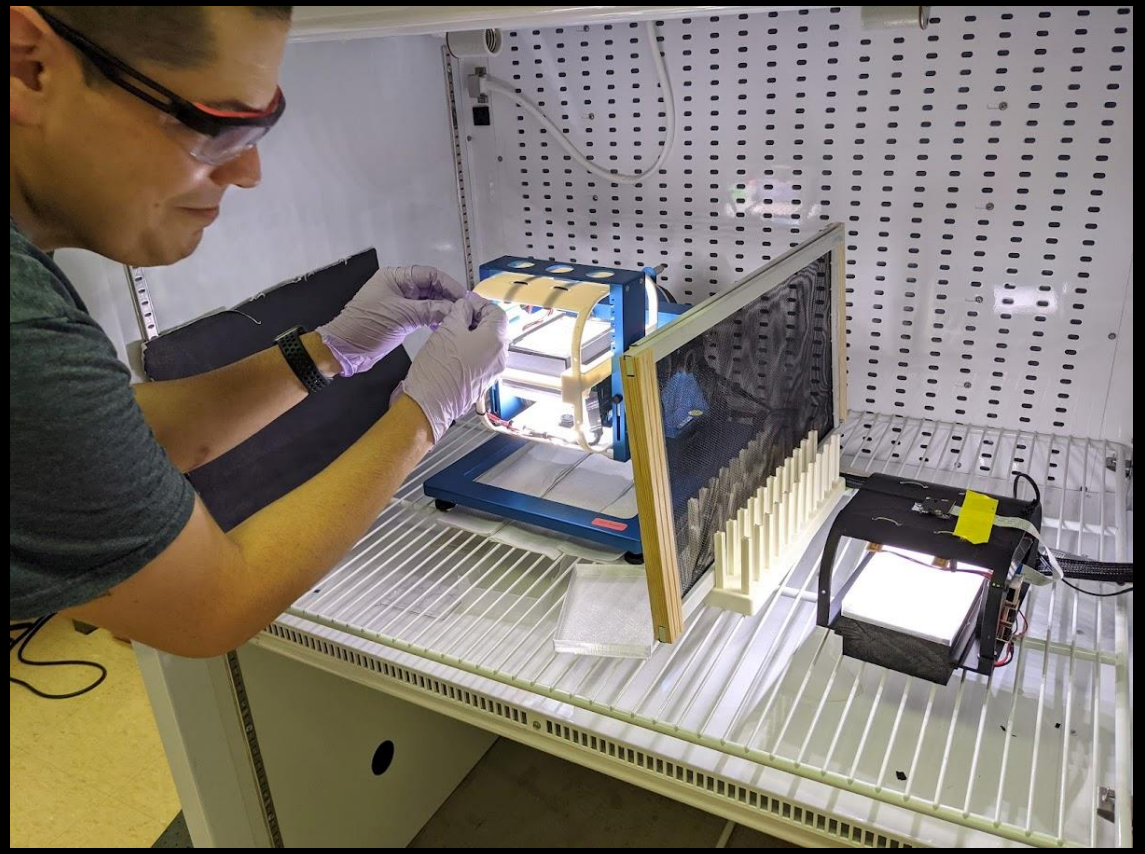
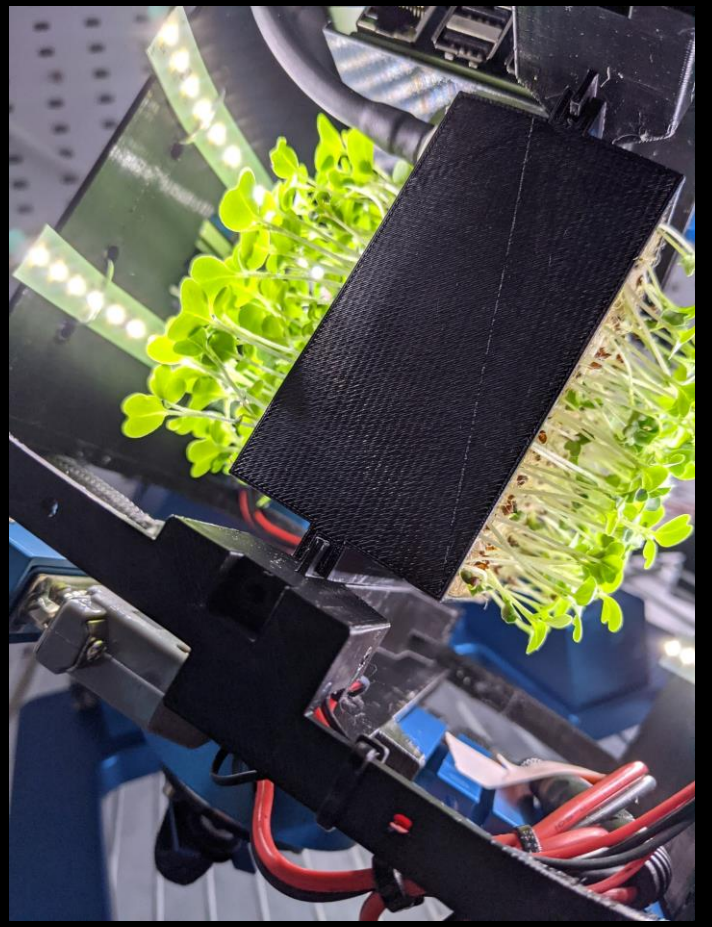
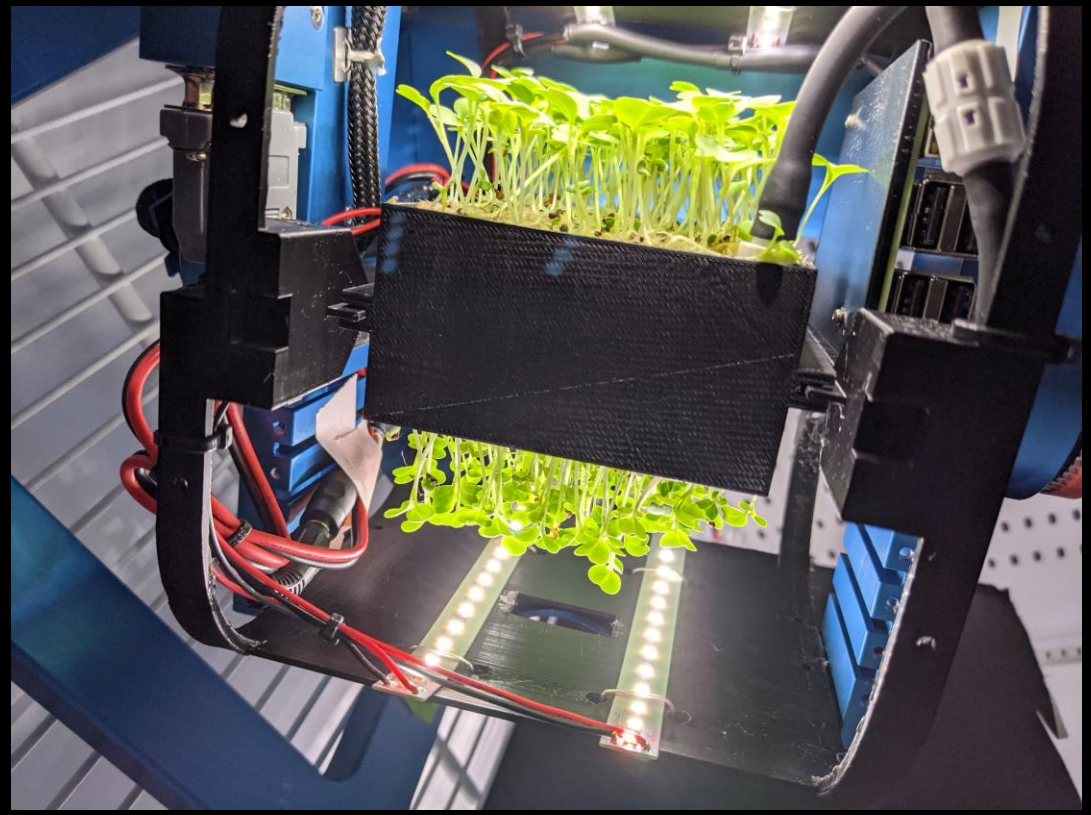




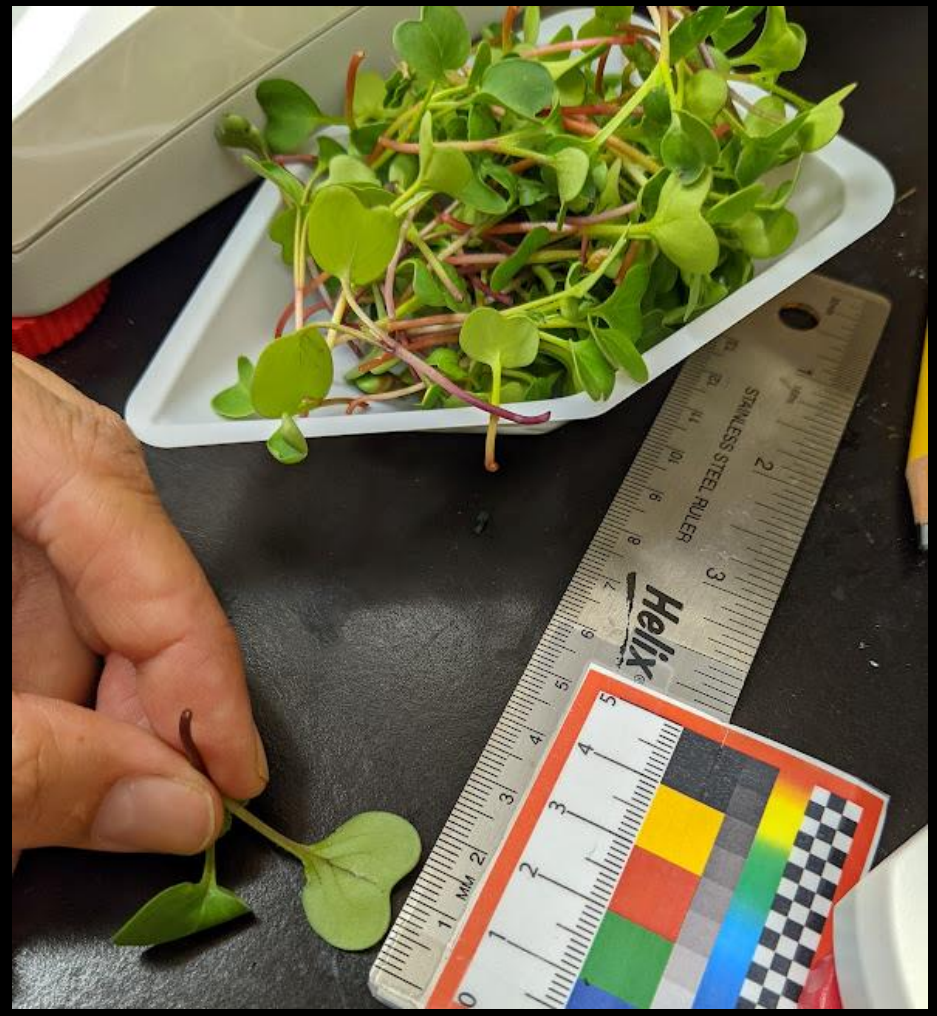
We started growing microgreens like a crop on Random Positioning Machines

Simulated Microgravity vs Stationary Control

- Preliminary data only at this point. Here are some pictures!



Radish microgreens growing in the specialized hydroponic grow box.

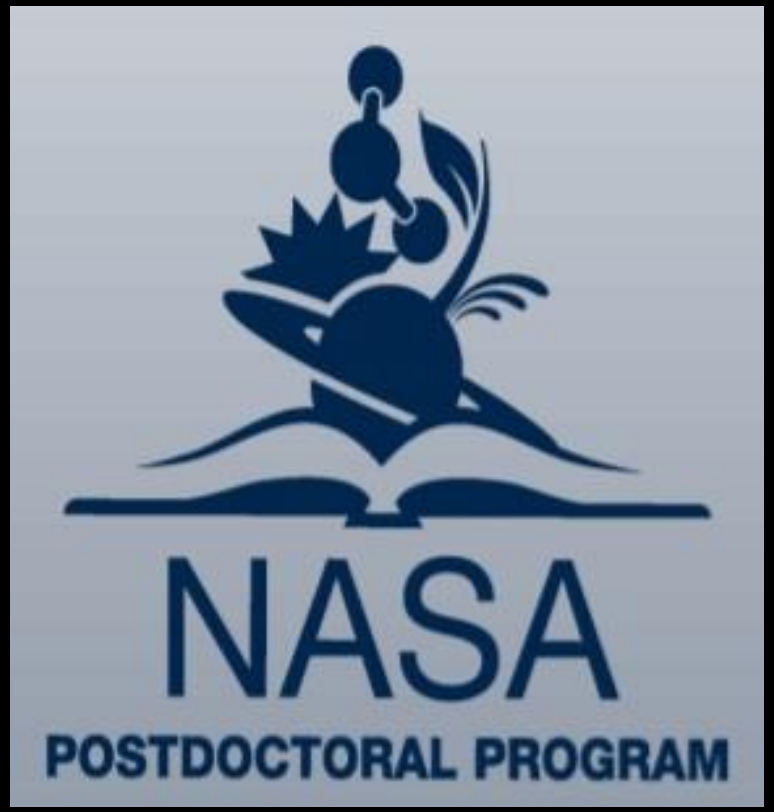


Harvesting one tray of microgreens

Summary:

- We need to feed astronauts
- Microgreens are a way to deliver freshly grown dense nutrition
- There are many challenges that we face when we grow plants in microgravity
- We bring in experts from everywhere to help us solve these problems.
- We are getting closer to growing this specialty crop in space.

NASA Postdoctoral Program



- All areas of NASA Science
- International postdocs welcome
- Check for opportunities today!